

CIM UTILITIES

BACKGROUND

1. Technical Field

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[0001] The present invention relates to management and control of resources in a computing system. More particularly, the invention concerns efficiently retrieving information concerning system resources such as storage resources.

10 2. Description of Related Art

[0002] Modern computing systems commonly include servers, storage systems, and other devices. Management and modeling programs are often used to manage the devices in computing systems.

15 [0003] Storage Management Initiative Specification (SMI-S) / Bluefin, and Common Information Model (CIM) technologies, are widely used for managing storage devices and storage environments. The SMI-S is a standard management interface that allows different classes of hardware and software products to interoperate for monitoring and controlling resources. For example, the SMI-S permits storage management systems
20 to identify, classify, monitor, and control physical and logical resources in a SAN. The SMI-S is based on CIM, and Web-Based Enterprise Management (WBEM) architecture. CIM is a model for describing management information, and WBEM is an architecture for using Internet technologies to manage systems and networks. The SMI-S uses CIM to define objects that represent storage entities such as Volumes, Disks, Storage
25 SubSystems, Switches, and host Computer Systems. (In many, but not all cases, the term "volume" is interchangeable with the term "Logical Unit Number" (LUN).) CIM also defines the associations that may or may not exist between these objects, such as a Disk being associated to a Storage SubSystem because it physically resides in the Storage SubSystem.

[0004] The CIM Objects mentioned above may be managed by a CIM Object Manager (CIMOM), also known as a CIM Server. A storage management software application, such as IBM Tivoli Storage Resource Manager (ITSRM), can use a CIM Client to connect to a CIMOM, to retrieve information about the storage entities that the CIMOM manages, and also to perform active configuration of the storage entities. Storage management software that uses a CIM Client may be called a CIM Client Application.

[0005] CIM Client Applications use a CIM Client API (Application Programming Interface) to communicate with a remote CIMOM. There are several CIM Client APIs available (SNIA, Pegasus, Java WBEM Services), and they all are similar in that the methods available to the CIM Client Application deal with the use of meta-data. CIM Client APIs include methods for the following common tasks:

- Get all instances of a certain CIM_Class
 - Example: Get all ComputerSystems
 - Example: Get all Hosts
- Get associated entities given a certain entity
 - Example: Get All StorageVolumes that are defined in a specific Disk Array StorageSystem
 - Example: Get the StoragePool that a particular StorageVolume is allocated from.

[0006] Using the CIM Client API to obtain commonly needed information from the CIMOM typically requires an excessive number of steps. As an example, Disk Array Storage Systems are modeled as ComputerSystems. The ComputerSystem's Dedicated property is used to identify the ComputerSystem as a Switch, Host, Disk Array System, or some other type of computer system. In addition, certain Disk Array information, such as Location, Model, and ProductID, are not modeled as properties of a Disk Array ComputerSystem, but rather as properties of objects associated to the ComputerSystem. Thus, to enumerate all Disk Array Systems and to get complete information about their properties, the following elaborate process is required:

1. Enumerate instances of Computer Systems;
2. Check each ComputerSystem's Dedicated property to identify if it is a Disk Array System;
3. Get the pertinent properties of the Disk Array Computer System, such as Name,
5 Description, and Status;
4. Get the associated PhysicalPackage object;
5. Get the Product object that is associated to the PhysicalPackage object;
6. Get the pertinent properties from the Product object, such as Name, Version, and Vendor;
- 10 7. Get the Location object that is associated to the PhysicalPackage object; and
8. Get the pertinent location information from the Location object.

Thus, this process requires an overly complex set of steps to discover and get the properties of Disk Array Computer Systems.

[0007] Additionally, when using the CIM Client API, it is not possible to get
15 information about a top-level entity and all of its components in one step. Component entities are modeled as separate objects, so an extra step is required to get information for each additional type of component object that the CIM Client Application is interested in. To get information about a Disk Array System and information about a specific subset of its components (Volumes, Storage Pools, FCPorts), the CIM Client must perform the
20 following operations:

1. Get information about the Disk Array System as described above;
2. Get the associated StorageVolume objects through SystemDevice associations;
3. Get the associated StoragePool objects through HostedStoragePool associations; and
4. Get the associated FCPort (Fibre Channel Port) objects through SystemDevice
25 associations.

Thus, the process for obtaining information about a Disk Array System and its components is overly complex.

[0008] In summary, known methods for using CIM Client Applications to obtain information pertaining to a single storage entity that may be distributed through

several objects in the CIM /SMIS model, are complex and require too many steps. Additionally, known methods for CIM Client Applications to obtain a top-level object and all of its components are excessively difficult. Further, with known methods, CIM Client Applications are unable to easily retrieve a complete view of a top level object and
5 its components, because WBEM (or CIM-XML) only allows for requests for targeted pieces of information.

SUMMARY

5 **[0009]** One aspect of the invention is a method for responding to an inquiry. An example of the method includes receiving the inquiry, obtaining information from a CIMOM, and creating at least one Storage Object. This example of the method also includes populating the at least one Storage Object with information received from the CIMOM, and sending the at least one Storage Object to a calling function.

10 **[0010]** Other aspects of the invention are described in the sections below, and include, for example, a computing system, and a signal bearing medium tangibly embodying a program of machine-readable instructions executable by a digital processing apparatus to perform a method for responding to an inquiry.

[0011] Some examples of the invention provide one or more of the following advantages:

1. Permitting a CIM Client Application to get all properties of a storage entity in one step, even though the properties of the storage entity may span several separate CIM
15 Objects in a CIMOM.
2. Permitting a CIM Client Application to retrieve complete information for a top level object (such as a Disk Array System) and all of its components in one step.
3. Permitting a CIM Client Application to get targeted information regarding
20 associations between top-level and component entities or between a component entity and another component entity, without requiring the CIM Client Application to retrieve complete information for the top-level entity.

Some examples of the invention also provide a number of other advantages and benefits, which should be apparent from the following description.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] FIG. 1 is a block diagram of the hardware components and interconnections of a computing system in accordance with an example of the invention.

5 [0013] FIG. 2 is a block diagram of the hardware components and interconnections of a computing system in accordance with an example of the invention.

[0014] FIG. 3 is a block diagram of the hardware components and interconnections of a computing system in accordance with an example of the invention.

[0015] FIG. 4 is an example of a signal-bearing medium in accordance an example of the invention.

10 [0016] FIG. 5 is a block diagram showing the relationship between SRM CIM Utilities, a CIM Client Application, and a CIM Client API, in accordance with an example of the invention.

15 [0017] FIG. 6 is a block diagram showing the relationship between components of SRM CIM Utilities, a CIM Client Application, and a CIM Client API, in accordance with an example of the invention.

[0018] FIG. 7 is a flowchart of an operational sequence for responding to an inquiry in accordance with an example of the invention.

DETAILED DESCRIPTION

[0019] The nature, objectives, and advantages of the invention will become more apparent to those skilled in the art after considering the following detailed description in connection with the accompanying drawings.

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I. HARDWARE COMPONENTS AND INTERCONNECTIONS

[0020] One aspect of the invention is a computing system that can be used for responding to an inquiry, for example, for managing resources associated with the computing system. As an example, the resources may be storage resources. The computing system may be embodied, for example, by all or portions of the computing system 100 shown in FIG. 1. The computing system 100 includes a first host server 102, a second host server 104, a first CIM server 106, a second CIM server 108, a first storage system 110, and a second storage system 112. (The host servers 102, 104 may be called hosts 102, 104.) Alternatively, in this embodiment and in the other embodiments discussed below, only one host could be included, or additional hosts could be included, and/or client computers could be included. Also, in this embodiment and in the other embodiments discussed below, only one CIM server could be included, or additional CIM servers could be included, or one or more CIM servers could be embedded in other devices. Also, in this embodiment or in the other embodiments discussed below, one or more ITSRM servers (not shown) could be included. The CIM servers 106, 108 may each be called a CIM Object Manager (CIMOM). Each host 102, 104, and the CIM servers 106, 108 may run the same or different operating systems, which could be any suitable operating system(s), for example, Windows 2000, AIX, Solaris™, Linux, UNIX, or HP-UX™. Each host 102, 104, and the CIM servers 106, 108 may be implemented with any suitable computing device, and may be implemented with the same, or different computing devices. As an example, hosts 102, 104 and CIM servers 106, 108 each could be a personal computer (having for example, an Intel processor running the Windows or Linux operating system), a computer workstation, a mainframe computer, a supercomputer (for example an IBM SP2 running the AIX operating system), or any

other suitable computing device running any suitable operating system. In other examples, the hosts 102, 104, and the CIM servers 106, 108 each could be an IBM xSeries server, or an IBM zSeries Parallel Sysplex server, such as a zSeries 900, running the z Operating System (z/OS), Windows 2000, Linux, or AIX, or could be an IBM S/390 server running OS/390. Hosts 102, 104 and CIM servers 106, 108 could also run Tivoli Storage Manager (TSM), which is available from IBM Corporation. The hosts 102, 104, and the CIM servers 106, 108 may be coupled to each other with a network 114, which may be an IP network, and which may use any suitable type of communications channel technology, for example, Ethernet, ESCON (Enterprise Systems CONnector), or FICON (Fiber CONnector). Additionally, network 114 could use the Internet, and could utilize wireless technology.

[0021] The host 102 has a processor 120 (which may be called a processing device), and in some examples could have more than one processor. As an example, the processor 120, may be a PowerPC RISC processor or an IBM P690 power 4 processor, available from International Business Machines Corporation. In another example, the processor 120 could be a processor manufactured by Intel Corporation. The host 102 also may have a memory subsystem that may include a primary memory 122 (for example RAM), and/or a non-volatile memory 124, both of which are coupled to the processor 120. The memory subsystem may be used to store data and application programs and/or other programming instructions executed by the processor 120. The application programs could include a CIM Client Application and could generally be any suitable applications. The CIM Client Application may have knowledge of, and may establish connections with, one or more of the CIM servers 106, 108.

[0022] The non-volatile memory 124 could be, for example, a hard disk drive, a drive for reading and writing from optical or magneto-optical media, a tape drive, non-volatile RAM (NVRAM), or any other suitable type of storage. In some examples the primary memory 122 or the non-volatile memory 124 could be eliminated, or the primary memory 122 and/or the non-volatile memory 124 could be provided on the processor 120, or alternatively, external from the host 102. The host 102 also has a hardware bus

adapter (HBA) 126, coupled to the processor 120, for coupling the host 102 via connector 128 to a Fibre Channel network (which may be called a “fabric) that may be used to implement a SAN 129. As an example, connector 128 may support FICON (Fiber CONnector), ESCON (Enterprise Systems CONnector) communications channels. As an example, the hardware bus adapter 128 could be a model 2200 hardware bus adapter available from QLogic Corporation. Generally, the SAN 129 may be implemented using Fibre Channel network(s) and/or Ethernet network(s). As will be discussed below, in other embodiments a SAN need not be included. Using the SAN 129 permits coupling a large number of storage devices to the hosts 102, 104.

[0023] Similar to host 102, host 104 has a processor 130, a memory subsystem that that may include a primary memory 132 (for example RAM), and/or a non-volatile memory 134, both of which are coupled to the processor 130. The memory subsystem may be used to store data and application programs and/or other programming instructions executed by the processor 130. The application programs could include a CIM Client Application and could generally be any suitable applications. The host 104 also has a hardware bus adapter 136, coupled to the processor 130, for coupling the host 104, via connector 138 (which may be similar to connector 128), to the Fibre Channel network that may be used to implement the SAN 129. In an alternative embodiment, SCSI protocol, rather than Fibre Channel protocol, could be used to couple the hosts 102, 104 to the SAN 129.

[0024] Similar to hosts 102, 104, CIM Server 106 has a processor 140, a memory subsystem that may include a primary memory 142 (for example RAM), and/or a non-volatile memory 144, both of which are coupled to the processor 140. The memory subsystem may be used to store data and application programs and/or other programming instructions executed by the processor 140. The application programs could generally be a CIM Object Manager program, and any other suitable applications. In some embodiments the CIM server 106 could be coupled to the SAN 129, and consequently, CIM server 106 could also have a hardware bus adapter for coupling the

CIM server 106 to the Fibre Channel network that may be used to implement the SAN 129.

5 **[0025]** Similar to the first CIM server 106, the second CIM server 108 has a processor 150, a memory subsystem that may include a primary memory 152 (for example RAM), and/or a non-volatile memory 154, both of which are coupled to the processor 150. The memory subsystem may be used to store data and application programs and/or other programming instructions executed by the processor 150. The application programs could generally be a CIM Object Manager program, and any other suitable applications. In some embodiments the CIM server 108 could be coupled to the SAN 129, and consequently, CIM server 108 could also have a hardware bus adapter for coupling the CIM server 108 to the Fibre Channel network that may be used to implement the SAN 129.

15 **[0026]** Storage system 110 includes storage devices 160a, 160b, storage controller 162, and hardware bus adapter 164. Similarly, storage system 112 includes storage devices 166a, 166b, controller 168, and hardware bus adapter 169. The storage systems 110, 112 could include additional storage devices. Storage system 110 is coupled to the SAN 129 via connector 172, and storage system 112 is coupled to the SAN 129 via connector 174. Connectors 172 and 174 may be similar to connectors 128 and 138 discussed above. There may be multiple paths to the storage systems 110, 112 in the SAN 129. Generally, a large number of storage systems may be coupled to the SAN 129. Also, storage devices that are not in storage systems could be coupled directly to the SAN 129, or could be coupled to the SAN 129 through a switch (not shown). The CIM servers 106, 108 are coupled to the storage systems 110, 112 via a network 176, which may be an IP network, and which may use any suitable type of communications technology such as discussed above with regard to network 114.

25 **[0027]** The storage devices 160a-b, 166a-b may be, for example, hard drives. However, each of the storage devices 160a-b, 166a-b could be implemented with any suitable type of storage device, using any suitable technology, such as magnetic, optical, magneto-optical, or electrical. For example, suitable storage devices could include hard

disk drives, optical disks or discs (for example, CD-RW, DVD-RW, or DVD+RW), floppy disks, magnetic data storage disks or diskettes, magnetic tape, digital optical tape, a tape library, EPROMs, EEPROMs, RAM, Non-Volatile RAM, and flash memory. Additionally, CD-R, WORM, DVD-R, and/or DVD+R devices could be included in the plurality storage devices. As an example, one or more of the storage systems 110, 112 could be implemented with a model F20 or model 800 Enterprise Storage Server, available from IBM Corporation. As another example, disk storage could be implemented with an IBM FAStT 900, and a tape library could be implemented with an IBM 3494 tape library using IBM 3590 drives, all of which are available from IBM Corporation.

[0028] An alternative computing system 200 is shown in FIG. 2. All or portions of the computing system 200 could be used to implement one or more examples of the invention. Computing system 200 includes host servers 102, 104, storage systems 110, 212, SAN 129, and IP network 214. Storage system 212 includes storage devices 216a, 216b, storage controller 218, and hardware bus adapter 219. The storage devices 216a-b may be any of the types of storage devices discussed above with regard to storage devices 160a-b, 166a-b. Storage system 212 further includes embedded CIM server 220. Thus, computing system 200 does not have a proxy CIM server, and the CIM server 220 is embedded in the storage system 212. CIM Server 220 has a processor 250, a memory subsystem that may include a primary memory 252 (for example RAM), and/or a non-volatile memory 254, both of which are coupled to the processor 250. The memory subsystem may be used to store data and application programs and/or other programming instructions executed by the processor 220. The application programs could generally be a CIM Object Manager program, and any other suitable applications. In the computing system 200, hosts 102, 104 and the CIM server 220 in storage system 212 are connected through the IP network 214. IP network 214 may use any suitable type of communications channel technology, for example, Ethernet, ESCON (Enterprise Systems CONnector), FICON (FIber CONnector). Additionally, network 214 could use the Internet, and could utilize wireless technology.

[0029] Another alternative computing system 300 is shown in FIG. 3. All or portions of the computing system 300 may be used to implement one or more examples of the invention. Computing system 300 includes host servers 102, 104, CIM server 106, and storage systems 310, 320, 330. Storage system 310 includes storage devices 350a, 350b, storage controller 352, and hardware bus adapter 354. Similarly, storage system 320 includes storage devices 360a, 360b, storage controller 362, and hardware bus adapter 364. Similarly, storage system 330 includes storage devices 370a, 370b, storage controller 372, and hardware bus adapter 374. The storage devices 350a-b, 360a-b, 370a-b may be any of the types of storage devices discussed above with regard to storage devices 160a-b, 166a-b. In the computing system 300, hosts 102, 104 and the CIM server 106 are connected through an IP network 376 which is similar to the network 114 discussed above. Hardware bus adapter 126 in host 102 couples host 102 to storage system 310 via connector 340 and the hardware bus adapter 354 in storage system 310. Similarly, hardware bus adapter 136 in host 104 couples host 104 to storage system 320 via connector 342 and the hardware bus adapter 364 in storage system 320, and also couples host 104 to storage system 330 via connector 344 and the hardware bus adapter 374 in storage system 330. As an example, connectors 340, 342, and 344 may support any suitable type of communications channel technology, for example, FICON (Fiber CONnector), ESCON (Enterprise Systems CONnector), or SCSI (Small Computer System Interface). CIM server 106 is coupled to storage systems 310, 320, and 330 via network 378, which may be an IP network, and which may use any suitable type of communications channel technology, for example, Ethernet, ESCON (Enterprise Systems CONnector), or FICON (Fiber CONnector). Additionally, network 378 could use the Internet, and could utilize wireless technology.

II. OPERATION

[0030] In addition to the hardware embodiments described above, another aspect of the invention concerns a method for responding to an inquiry.

A. Signal-Bearing Media

[0031] In the context of FIGS. 1-3 the method aspect of the invention may be implemented, for example, by having host 102, host 104, CIM server 106, CIM server 108, or CIM server 220 execute a sequence of machine-readable instructions, which can also be referred to as code. These instructions may reside in various types of signal-bearing media. In this respect, one aspect of the present invention concerns a programmed product, comprising a signal-bearing medium or signal-bearing media tangibly embodying a program of machine-readable instructions executable by a digital processing apparatus to perform a method for responding to an inquiry.

[0032] This signal-bearing medium may comprise, for example, primary memory 122 and/or non-volatile memory 124, primary memory 132 and/or non-volatile memory 134, primary memory 142 and/or non-volatile memory 144, primary memory 152 and/or non-volatile memory 154, and/or, primary memory 252 and/or non-volatile memory 254. Alternatively, the instructions may be embodied in a signal-bearing medium such as the optical data storage disc 400 shown in FIG. 4. The optical disc can be any type of signal bearing disc or disk, for example, a CD-ROM, CD-R, CD-RW, WORM, DVD-R, DVD+R, DVD-RW, or DVD+RW. Additionally, whether contained in the computing system 100, 200 or 300, or elsewhere, the instructions may be stored on any of a variety of machine-readable data storage mediums or media, which may include, for example, a "hard drive", a RAID array, a RAMAC, a magnetic data storage diskette (such as a floppy disk), magnetic tape, digital optical tape, RAM, ROM, EPROM, EEPROM, flash memory, magneto-optical storage, paper punch cards, or any other suitable signal-bearing media including transmission media such as digital and/or analog communications links, which may be electrical, optical, and/or wireless. As an example, the machine-readable instructions may comprise software object code, compiled from a language such as "C++", or may comprise Java bytecode.

B. Main Functional Units

[0033] Referring to FIG. 5, some examples of the invention may be called “SRM CIM Utilities for Storage Reporting and Discovery” 502, referred to as the “SRM Client CIM Utilities”. The SRM CIM Utilities 502 is a set of code modules that is an intermediary between a CIM Client Application 504 on one end and a CIM Client API 506 on the other end. The CIM Client API 506 is the interface to a library that the SRM CIM Utilities 502 use, and may be called the CIM Client library. The SRM CIM Utilities 502 simplifies and abstracts the Common Information Model for Storage and the CIM Client API 506, allowing Storage Resource Management CIM Client Applications 504 to more easily retrieve information about storage resources from a CIMOM 106, 108. A CIMOM can be used for managing many types of resources. Consequently, any resources managed by CIMOMs may benefit by the SRM CIM Utilities 502 as described herein for some examples of the invention. The SRM CIM Utilities 502 may be used specifically for Storage Resource Management, but also could be used for SAN Management through CIM, or for management of other resources or networks through CIM. For example, the SRM CIM Utilities 502 could be used to manage one or more of any of the following:

- a Fibre Channel switch;
- a tape library;
- an inband virtualization device, for example, an IBM SAN volume controller, (wherein the server virtualizes volumes and is accessed as a disk array device);
- an out of band virtualization device;
- a HBA (host bus adapter) on another host;
- a router; or
- network attached storage.

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[0034] FIG. 6 illustrates the three main functional units (also called parts) of the SRM CIM Utilities 502, which are: Storage Objects 602, an Object Retrieval Tool 604, and a CIM Discover Tool 606. The three parts interoperate with each other and with the CIM Client Application 504 and the CIM Client API 506.

Storage Objects 602:

5 **[0035]** The following is a discussion of the Storage Objects 602: The Storage Objects 602 are a Java package comprised of classes that define several storage entity objects, including Disk Array Systems, Storage Pools, Volumes, Host Systems, FCPorts, and Disks. In alternative embodiments, programming languages other than Java could be used. In an example of the SRM CIM Utilities 502 managing a Disk Array System, the Disk Array System is the top level object, with all other objects being associated as a component of the top level object or as a subcomponent of another component object.

10 The Storage Objects' associations to each other reflect the storage entities' relationships as they are modeled in SNIA SMI/Bluefin Profiles. The properties of the Storage Objects directly map to the properties of the CIM Classes that are used to represent the storage entity. For example, the Storage Objects' DiskArraySystem objects' properties map directly to properties defined in the following CIM classes: CIM_ComputerSystem,

15 CIM_Product, and CIM_Location. The Storage Objects' Volume object's properties map directly to properties defined in the CIM_StorageVolume class.

[0036] The following operations may be performed to produce the Storage Objects 602: Identify entities and subcomponent entities of a class of device to be managed. For example, if managing a disk array, identify the disk array and attached

20 entities, for example disks and volumes. Also, identify the parent-child relationships between the entities. As an example, a disk may be a child of a storage pool, and the storage pool and the disk may be children of a disk array.

Object Retrieval Tool 604:

25 **[0037]** The following is a discussion of the Object Retrieval Tool 604: The Object Retrieval Tool 604 is a Java module or set of Java modules that allows callers to make small and specific inquiries concerning storage entities that are managed by a CIMOM 106, 108. In alternative embodiments, programming languages other than Java

could be used. The Object Retrieval Tool 604 may be called directly by the SRM CIM Client 504 Application or by the CIM Discover Tool 606.

[0038] For each inquiry that the Object Retrieval Tool 604 receives, the Object Retrieval tool 604 does the following:

- 5 1. The Object Retrieval Tool 604 uses the CIM Client API 504 to get the requested information from the CIMOM 106, 108;
2. The Object Retrieval Tool 604 creates a Storage Object or a set of Storage Objects 602;
3. The Object Retrieval Tool 604 populates the Storage Object(s) 602 with information
10 received from the CIMOM 106, 108; and
4. The Object Retrieval Tool 604 returns the Storage Objects 602 to the calling function.

[0039] The Object Retrieval Tool has two primary types of tasks:

1. Given a storage entity's unique ID, get the Storage Object. Examples of this are: Get
a Disk Array System's Storage Object given a Disk Array System's unique ID; Get a
15 Volume's Storage Object given a volume's unique ID; Get a Storage Pool's Storage
Object given a Storage Pool's unique ID.
2. Given a storage entity's unique ID, get all associated storage entities of a certain type.
Examples of this are: Get all component Volumes given a Disk Array System's unique
ID; Get all component Storage Pools, given a Disk Array System's unique ID; Get all
20 volumes that a Host System can access, given the Host System's unique ID.

CIM Discover Tool 606:

[0040] The following is a discussion of the CIM Discover Tool 606: The CIM Discover Tool 606 is a Java module or set of Java modules that allow callers to obtain
25 large amounts of information from a CIMOM 106, 108 with just one step. In alternative
embodiments, the CIM Discover Tool 606 could be implemented in different
programming languages. The CIM Discover Tool 606 uses the Object Retrieval Tool's
604 methods to fulfill a caller's request, and thus never directly calls the CIM Client API

506. The CIM Discover Tool 606 may be thought of as an API for management software applications using CIM.

[0041] The CIM Discover Tool 606 has three primary types of tasks:

- 5 1. Given a top level storage entity's unique ID, get all information about the storage entity and all of its components. An example of this is: Get Storage System Detail, including all component entity information (Volumes, Disks, DiskGroups, StoragePools, FCPorts, etc.). Returned information includes all relationships between component entities.
- 10 2. Given a component storage entity's unique ID, get all information about the storage entity and its subcomponents or relationships to other components. These tasks allow the calling function to get "sub-views" of the larger picture. This is the "middle ground" between getting information on the whole view or just a very small piece of information. An example of this is: Get StoragePool Detail, including a subcomponent entity information (Volumes and Disks).
- 15 3. Given a top-level storage entity type and a specific CIMOM, get all information about all entities of this storage entity type managed by this CIMOM, and all of their respective components. An example of this: Get StorageSystem Details Given CIMOM including all component entity information (Volumes, Disks, DiskGroups, StoragePools, FCPorts, etc.). Returned information includes all relationships between component entities. The
- 20 CIM Discover Tool 606 then forwards this request to the Object Retrieval Tool 604. The Object Retrieval Tool 604 makes a call to the CIM Client Library to get information about the existence of top-level entities of this type. Then, for each top-level entity, corresponding calls to the CIM Client Library, using the unique IDs of the entities, are made as usual.

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C. Overall Sequence of Operation

[0042] For ease of explanation, but without any intended limitation, the method aspect of the invention is described with reference to the computing system 100 described above and shown in FIG. 1. An example of the method aspect of the present invention is

illustrated in FIG. 7, which shows a sequence 700 for a method for responding to an inquiry. As an example, the operations in the sequence 700 may be performed by host 102 or host 104. Alternatively, the operations could be performed by CIM server 106 or CIM server 108, or any suitable computing device in computing system 100 (which could include an ITS RM server).

[0043] Referring to FIG. 7, the sequence 700 may include, and begin with, operation 702 which comprises receiving an inquiry. As an example, the inquiry may be an inquiry for information concerning a storage entity. The inquiry may be received, for example, from a SRM CIM Client Application. Alternatively, the inquiry may be received from a CIM Discover Tool. As an example, the inquiry may include the unique ID of a designated storage entity, may be a request for a Storage Object corresponding with the designated storage entity. As another example, the inquiry may include the unique ID of a designated storage entity, and may be a request for all storage entities of a specified type associated with the designated storage entity. As another example, the inquiry may not include the unique ID of a designated storage entity, and may be a request for all storage entities of a specified top-level storage entity type.

[0044] Sequence 700 may also include operation 704, which comprises obtaining information from a CIMOM 106. Operation 704 may comprise using a CIM Client API to obtain requested information from the CIMOM 106.

[0045] Sequence 700 may also include operation 706, which comprises creating at least one Storage Object. Operation 706 may comprise creating a set of Storage Objects. Each Storage Object may be created by using a Java package comprising classes that define a plurality of storage entity objects. The plurality of storage entity objects may include Disk Array System, Storage Pool, Volume, Host System, FCPort (Fibre Channel Port), and Disk, objects. As an example, the Disk Array System object may be a top level object, and each object other than the Disk Array System object may be associated as a component of the Disk Array System object. As another example, for SAN Management, the top-level object may be an object that represents a SAN Fabric, and in another example, for management of a FibreChannel Switch, the top-level object

may be an object that represents a FibreChannel Switch. In another example, the Disk Array System object may be a top level object, and at least one object other than the Disk Array System object may be a subcomponent of an object other than the Disk Array System object. In another example, the creating operation 706 may comprise creating a plurality of Storage Objects, wherein the Storage Objects have associations to each other that are consistent with corresponding storage entities' relationships modeled in a SMI/Bluefin profile. In another example, the creating operation 706 may comprise creating a plurality of Storage Objects, wherein properties of each Storage Object map directly to properties of at least one CIM Class used to represent a corresponding storage entity.

[0046] Sequence 700 may also include operation 708, which comprises populating the at least one Storage Object with information received from the CIMOM 106. Sequence 700 may also include operation 710, which comprises sending the at least one Storage Object to a calling function.

[0047] Sequence 700 may also include operation 712, which comprises determining if a request, for example received from the CIM discover tool, requires an additional inquiry. If so, operations 702-710 may be repeated. As an example, the inquiry may include the unique ID of an identified top level storage entity, and the receiving 702, obtaining 704, creating 706, populating 708, and sending 710 operations may be repeated to obtain information concerning the identified top level storage entity and all of the components of the identified top level storage entity. As another example, the inquiry may include the unique ID of a component storage entity, and the receiving 702, obtaining 704, creating 706, populating 708, and sending 710 operations may be repeated to obtain information concerning the component storage entity and subcomponents of the component storage entity. In another example, the inquiry may include the unique ID of a component storage entity, and the receiving 702, obtaining 704, creating 706, populating 708, and sending 710 operations may be repeated to obtain information concerning the component storage entity and the component storage entity's relationships to other components.

[0048] Many examples of the invention will benefit developers working on a CIM Client Application because these examples reduce development time and improve code maintainability, which allows for faster time to market for a CIM Client Application product.

5 [0049] The following are some examples of unique benefits of utilizing the SRM CIM Utilities 502:

- Simplifies a CIM Client Application's 504 code for retrieving information from a CIMOM 106, 108:
 - 10 ○ Provides the ability to retrieve large amounts of information pertaining to a Storage Environment with one method call.
 - Provides the ability to retrieve specific pieces of information pertaining to a Storage Environment with simplified method calls.
- No Code Redundancy:
 - 15 ○ The CIM Discover Tool 606 builds upon the Object Retrieval Tool 604. All CIM Discover Tool calls may be designed as a sequence of Object Retrieval Tool calls.
 - The design allows for easy code maintenance.

III. OTHER EMBODIMENTS

20 [0050] While the foregoing disclosure shows a number of illustrative embodiments of the invention, it will be apparent to those skilled in the art that various changes and modifications can be made herein without departing from the scope of the invention as defined by the appended claims. Furthermore, although elements of the invention may be described or claimed in the singular, the plural is contemplated unless
25 limitation to the singular is explicitly stated.